SINGLE-PHASE SOLID STATE AC RELAY (OPTOTHYRISTOR MODULE) WITH CURRENT OVERLOAD PROTECTION, WITH PROTECTION AGAINST LOAD OPENING CIRCUIT AND OVERHEAT
MO8MA-T

USER'S MANUAL

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CONTENTS

1 DESCRIPRION AND FUNCTION

Single-phase solid state AC Relay (optothyristor module) with current overload protection, with protection against break in load circuit and against overheating MO8MA-T (hereinafter - module or MO8MA-T) is intended for load switching in AC circuits from 50 Hz to 400Hz with current overload protection, protection against break in load circuit and against overheating as well as error status availability when emergency.

MO8MA-T is made on basis of modern technology achievements of power electronics, microelectronics, digital-to-analogue integrated circuits and controllers of digital and analogue signal processing with the integral PWM circuits.

MO8MA-T supports the following functions:

- Load switching in AC circuits from 50 Hz to 400 Hz;
- Wide variety of devices for diverse switch current from 25 A to 320 A;
- Processing of switching current with built-in shunt (for devices of 25 A, 40 A, 63 A, 80 A) or with external current-measuring transformer that is completed with the module (for devices of 100 A, 120 A, 160 A, 200 A, 250 A, 320 A);
- Force-summing switching elements of 12-th or 16-th class for breakdown voltage;
- Protection of force-summing elements and switching load against current overload and load circuit break;
- Overheating protection of force-summing elements;
- Signaling On-LED (green) and Emergency-LED (red);
- Status emergency signals: for T1 – one general status optically isolated signal for current overload, load circuit break and overheating; for T3 – three separate status optically isolated signals of current overload, load circuit break and overheating;
- Protection against misconnection of input control voltage;
- Control of input circuit integrity.

MO8MA-T provides load switching up to 250 kW (for force-summing elements of 16 class). MO8MA-T is produced with radiator of diverse rated current and voltage classes, with wide range of input control voltage that allows using the module both for solution of industrial problems and of special cases.

2 MODULE TYPES

MO8MA-T is produced with different types of radiators and different measure methods of switching current as well as with different quantity of status signals.

In sections 5 and 6 there are the recommended connection circuits of the modules depending on the version.

MO8MA-T are produced at 25, 40, 63, 80, 100, 120, 160, 200, 250, 320 A and at 1200 or 1600 V of force-summing elements. The current in module name indicates maximum rms current at which protection processing circuit allows commutating the relay. When exceeding the maximum rms current then current protection will work and disable the force-summing elements of the module. Maximum voltage in module

name indicates maximum permissible anode-cathode voltage that is used in power thyristor module. MO8MA-T is made at 1200, 1600 V that corresponds to the values 12 and 16 in module name. In addition to that the maximum-permissible switch voltage of the module is lower than it is specified in the name of the module (ref. to section 4).

Measurement of switching current by means of built-in shunt:

25, 40, 63, 80 A. Relay modifications are possible at 1200 and 1600 V of force-summing elements, with one common or three separate status signals.

Measurement of switching current by means of external current-measuring transformer:

Modules at 100, 120, 160, 200, 250, 320 A. Relay modifications are possible at 1200 and 1600 V of force-summing elements, with one common or three separate status signals.

Figure 2.1 shows the decoding of module name series MO8MA-T.

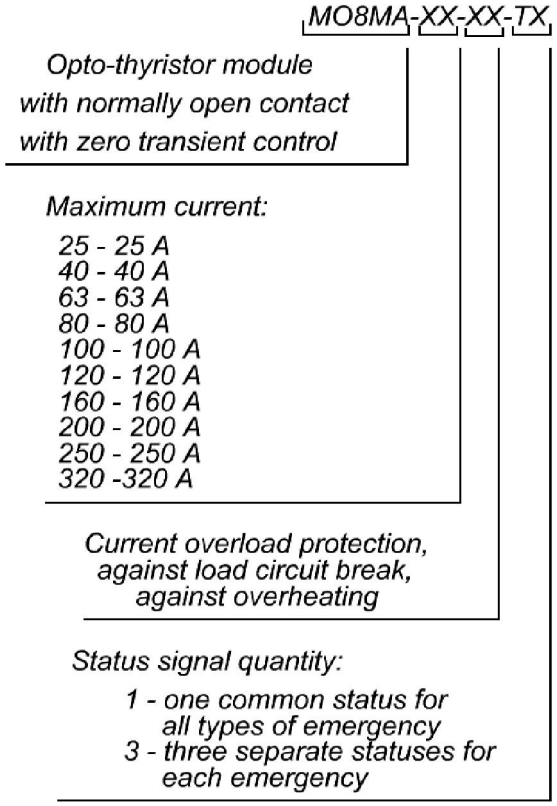


Figure 2.1 – Decoding of module name

For instance, module MO8MA-120-12-T3: three-phase solid state AC relay with current overload protection, with protection against load circuit break and overheating MO8MA-T with maximum switching current 120 A, maximum voltage of force-summing elements 1200 V with three separate error statuses to each emergency.

3 GENERAL MODULE DESCRIPTIONS

Structure module circuit MO8MA-T is shown at Figure 3.1.

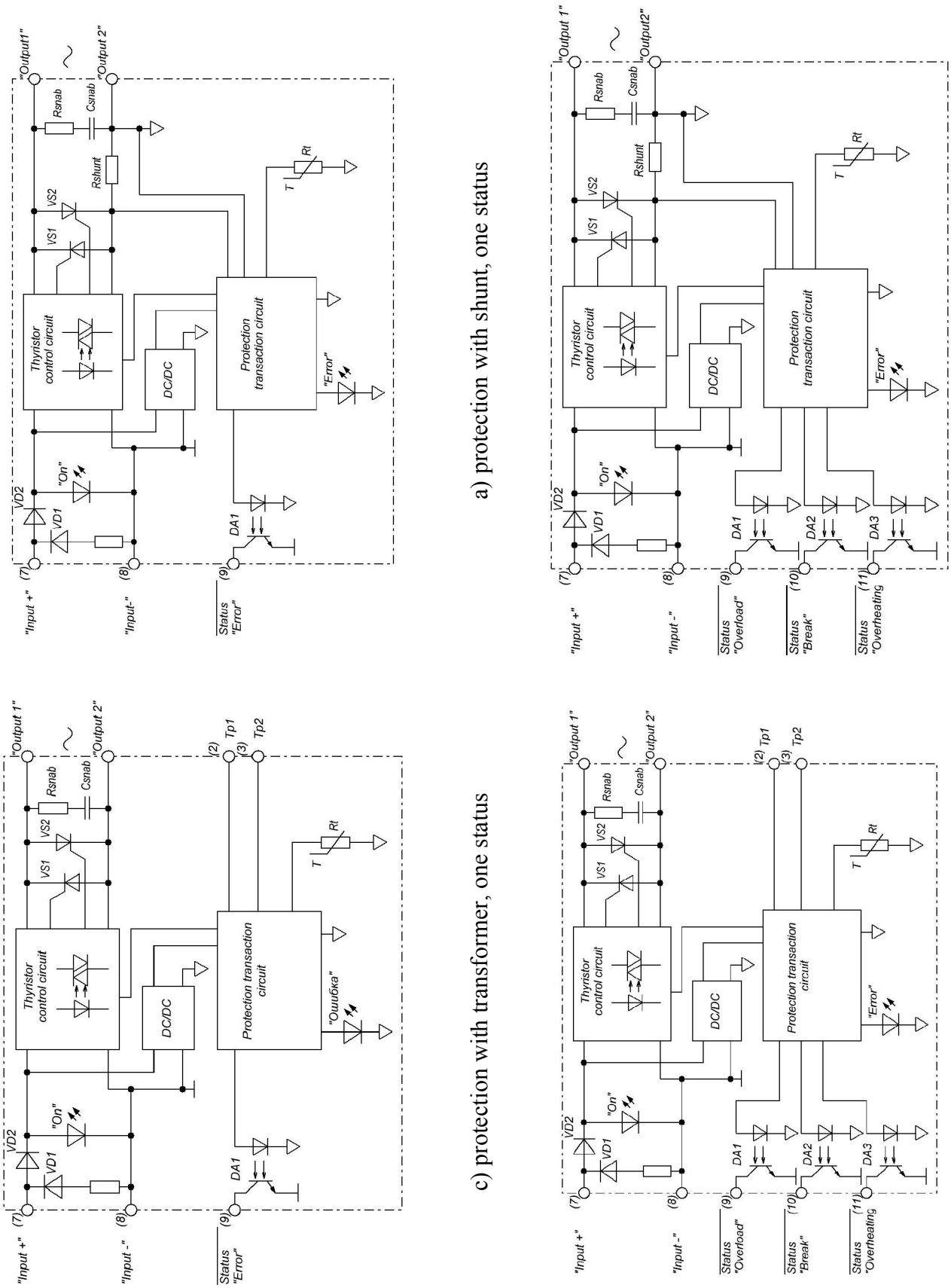


Figure 3.1 – Structure circuit of MO8MA-T

Input pins, connection contacts of statuses and measuring transformer are a lugs knife terminal, power contacts – threaded contacts under screw or bolt (ref. to overall dimensions). The output functions of the module are represented in Table 3.1.

Table 3.1 – Output function of the module

Contact #	Symbol	Function
7	Input +	Positive output of input control signal
8	Input -	Negative output of input control signal
9	Status «Overload»	Optically isolated error signal when current overload in relay modification with three separate error statuses.
	Status «Error»	Optically isolated error signal when current overload, load circuit break and overheating in relay modification with one common error status.
10	Status «Break»	Optically isolated error signal when load circuit break
11	Status «Overload»	Optically isolated error signal when module overheating
2	Tr1	Input №1 for connection of external current-measuring transformer in relay modification with external current-measuring transformer
3	Tr2	Input №2 for connection of external current-measuring transformer in relay modification with external current-measuring transformer
	Output 1	Power output for load connection.
	Output 2	Power output for load connection.

4 BASIC CHARACTERISTICS

Basic electric characteristics and maximum-permissible electric characteristics of MO8MA-T at 25 ^{0}C are shown in Table 4.1 and 4.2.

Table 4.1 – Basic and maximum permissible electric characteristics of control circuits

Name	Unit	Value			Note
		min	typ.	max	
Input characteristics					
On-state input voltage, $U_{in.on}$	V	10		32	
Off-state input voltage, $U_{in.off}$	V			3	
Current consumption, I_{cons}	mA	20		50	
Status signal characteristic					
Maximum collector-emitter voltage, $U_{c\text{-}e.stat}$	V			55	
Maximum current, $I_{c.stat}$	mA			20	
Collector-emitter voltage drop, $U_{d.stat}$	V			5	at 10 mA
Output characteristics					
Maximum off state output peak voltage, U_{peak}	V			±1200	MO8MA-XX-12-TX
				±1600	MO8MA-XX-16-TX
Switching current, rms value, I_{com}	A	2.5		25	MO8MA-25-XX-TX
				40	MO8MA-40-XX-TX
				63	MO8MA-63-XX-TX
				80	MO8MA-80-XX-TX
				100	MO8MA-100-XX-TX
				120	MO8MA-120-XX-TX
				160	MO8MA-160-XX-TX
				200	MO8MA-200-XX-TX
				250	MO8MA-250-XX-TX
				320	MO8MA-320-XX-TX
Switching voltage, rms value, U_{com}	V	~30		~630	MO8MA-XX-12-TX
				~840	MO8MA-XX-16-TX
Switching pulse current, $I_{com.p}$ at pulse time max 10 ms	A			250	MO8MA-25-XX-TX
				400	MO8MA-40-XX-TX
				630	MO8MA-63-XX-TX
				800	MO8MA-80-XX-TX
				1000	MO8MA-100-XX-TX
				1200	MO8MA-120-XX-TX
				1600	MO8MA-160-XX-TX
				2000	MO8MA-200-XX-TX
				2500	MO8MA-250-XX-TX
				3200	MO8MA-320-XX-TX
Instantaneous current magnitude when operating of overload protection, $I_{ovh.inst}$	A			35	MO8MA-25-XX-TX
				56	MO8MA-40-XX-TX
				89	MO8MA-63-XX-TX
				113	MO8MA-80-XX-TX
				141	MO8MA-100-XX-TX
				169	MO8MA-120-XX-TX
				226	MO8MA-160-XX-TX
				282	MO8MA-200-XX-TX
				353	MO8MA-250-XX-TX
				451	MO8MA-320-XX-TX

Continuation of Table 4.1

Name	Unit	Rate			Note
		min	typ.	max	
Turn-on inhibit voltage, Uinh	V			40	Uin=10 V
Critical rate of rise of output current, dI/dt	A/μs			160	
Critical rate of rise of output voltage, dU/dt	V/μs			500	
Off-state output leakage current, Il.out.	mA			±3	Uin.=3 V, Uout= ±1200 V for relay of 12 class, Uout= ±1600 V for relay of 16 class
Output residual voltage, Ures	V			1.5	Uin=10 V, Iout=1.41·Icom
Time characteristics					
On time, ton	ms			10	Fnet = 50Hz
				1.25	Fnet = 400 Hz
Off time, toff	ms			10	Fnet= 50 Hz
				1.25	Fnet = 400 Hz
Turn-off delay when operating of current overload protection, td.ov	ms			10	Fnet = 50 Hz
				1.25	Fnet = 400 Hz
Turn-off delay when operation of protection against load break, td.br	ms	20		100	
Turn-off delay when operation of overheating protection, td.temp.	ms			10	Fnet = 50 Hz
				1.25	Fnet = 400 Hz
Turn-on delay time of signal “Overload” when excess of instantaneous current value of load protection operation td.stat.ov.	ms			5	
Turn-on delay time of signal “Overheating” when excess of maximum module temperature td.stat.temp.	ms			5	
Turn-on delay time of signal “Break” when load break td.stat.break	ms	20		100	
Temperature characteristics					
Temperature of overheating protection operation, Tr.	°C	85		95	
Thermal junction-radiator resistance, Rth j-r	°C/W			1	MO8MA-25-XX-TX
				0.7	MO8MA-40-XX-TX
				0.6	MO8MA-63-XX-TX
				0.45	MO8MA-80-XX-TX
				0.3	MO8MA-100-XX-TX
				0.25	MO8MA-120-XX-TX
				0.23	MO8MA-160-XX-TX
				0.19	MO8MA-200-XX-TX
				0.15	MO8MA-250-XX-TX
				0.1	MO8MA-320-XX-TX
Isolation characteristics					
Isolation voltage, U_{isol}	V			4000	DC, 1 minute

5 MODULE CONTROL

We recommend the following connection circuits (Fig. 5.1 – 5.2).

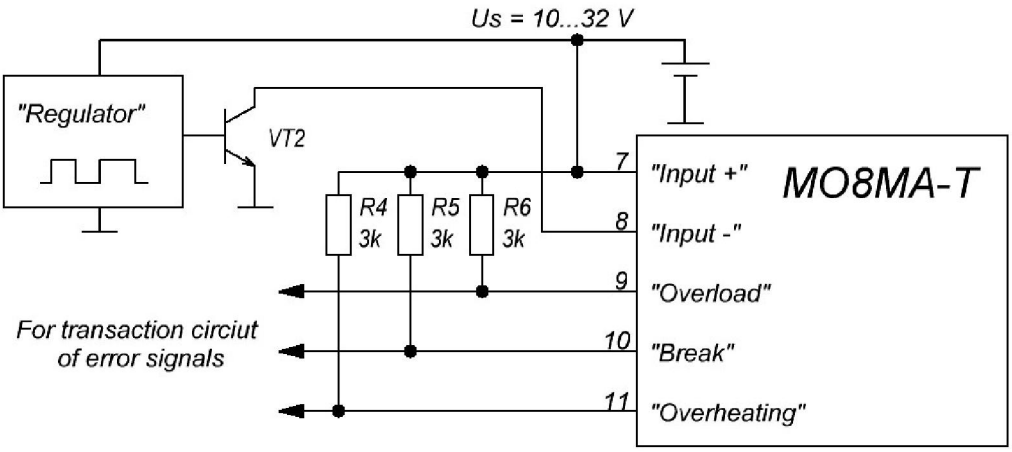


Figure 5.1 – Connection circuit MO8MA-T with regulator and three error statuses.

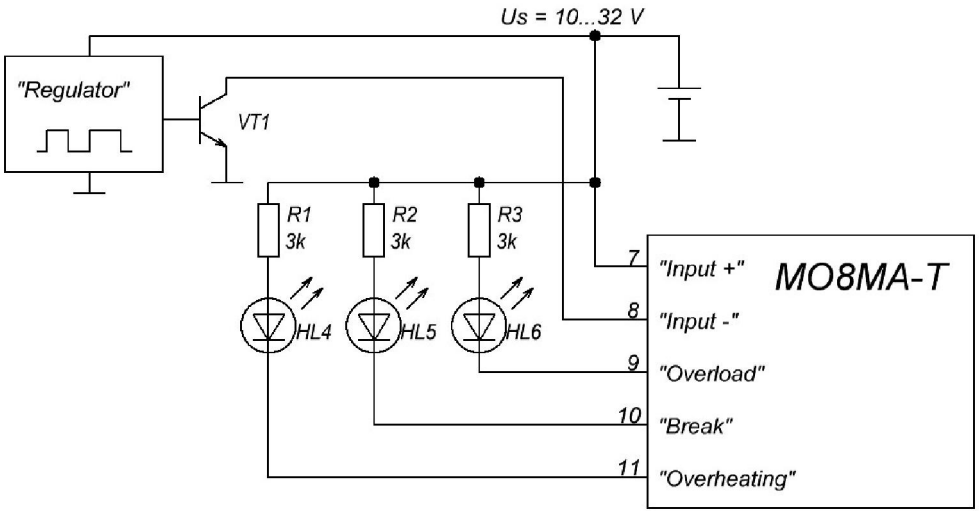


Figure 5.2 – Connection circuit MO8MA-T with regulator and three errors LED.

Figure 5.1 shows connection circuit with three error signals that may be used for information processing about an emergency by means of module control circuit.

Figure 5.2 shows connection circuit with three error LEDs that may be used for distant emergency signaling.

It is permissible to use one of the error signals for module reset and the other error statuses only as signaling.

The connection of the module with one common error status of current overload, load break or overheating like MO8MA-XX-XX-T1 is similar to the connection that is shown at Figure 5.1-5.2. It is useful to apply the module with one error status if commutation block of the module for some reason is not critical.

The diagrams that explain the operation of MO8MA-T under some kinds of emergency are shown at Figures 5.3 - 5.5.

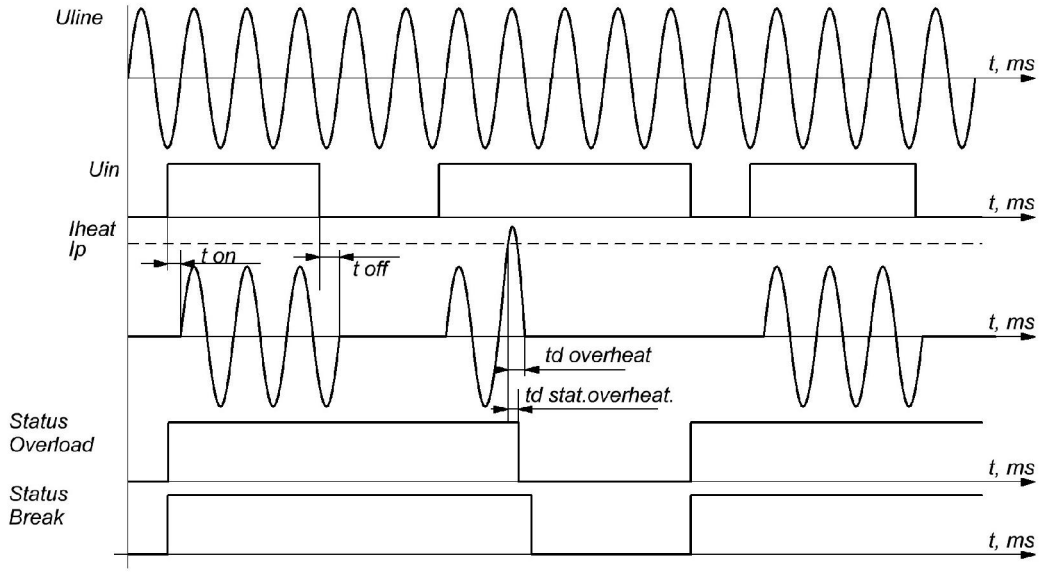


Figure 5.3 – The diagram of module operation when current overload.

Figure 5.3 gives the diagram of module operation when current overload. If the load current value is more than $I_{overheat} = 1.41 \cdot I_{com}$ then the module will be switched off with turn-off delay $td_{.overheat}$. The status "Overload" will be turned on with delay $td_{.stat.overheat}$, the status "Break" will be turned on with delay $td_{.stat.break}$. It is necessary to make a reset the input control voltage to remove switch block of the module.

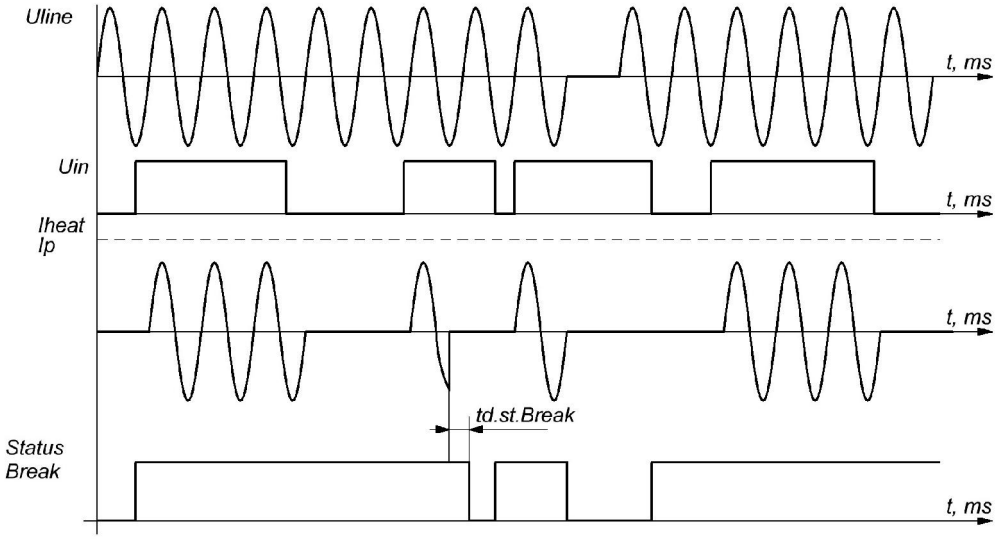


Figure 5.4 – Diagram of module operation when load break.

Figure 5.4 shows the diagram of module operating when load circuit break. представлена диаграмма функционирования модуля при обрыве в цепи нагрузки. If the current that flows through the module is lower than 2,5 A, if there is full load circuit break as well as power switch voltage at least for 20…100 ms, then the switch blocking of the module will occur and the module will be turned off with delay td.break. The status "Break" will be turned on with delay td.stat.break. To remove the switch lock of the module it is necessary to make a reset input control voltage.

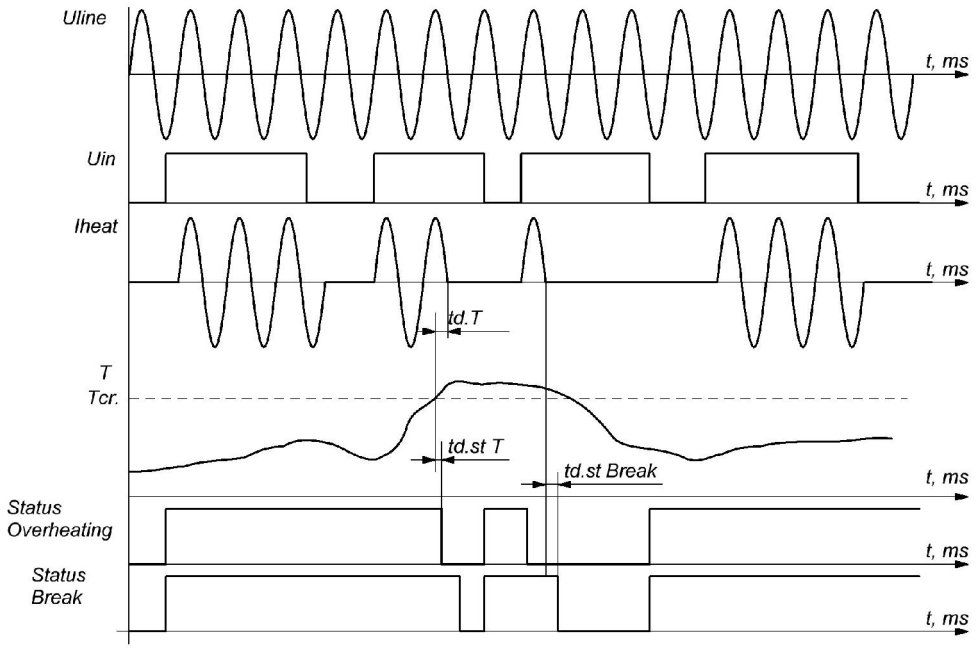


Figure 5.5 – Diagram of module operating when overheat

Figure 5.5 shows the diagram of module operating when overheating. If the radiator temperature is more than Tcr = 85…95 °C then switch block of the module and turn-off with delay td. temp will occur. The status "Overheating" will be turned off with delay td.stat.t, the status "Break" will be turned off with delay c td.stat.break. It is necessary to make a reset input control voltage to remove switch block of the module.
If module reset is performed within a time when radiator temperature is higher than Tcr, then the module will be disconnected again and it lasts until radiator temperature is reduced lower than Tcr.

If any of module protections operate then the built-in red LED "Error" will be switched on that may be an alarm on conditions that the other signaling methods are not used. When supplying of input control voltage to the module the built-in green LED "On" will be switched on that signals about module turning-on.

The diagrams of module functioning with one common status do not have any differences in the main from the diagram for module with three separate statuses. EMERGENCY turn-off delays do not have any differences from those of the module with three statuses, ERROR turn-on delays are analogous to the ERROR turn-on delays of the module with three statuses with the difference that all of them are formed on one ERROR status.

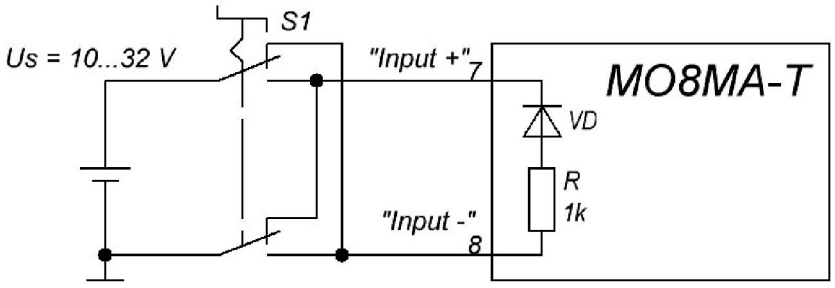
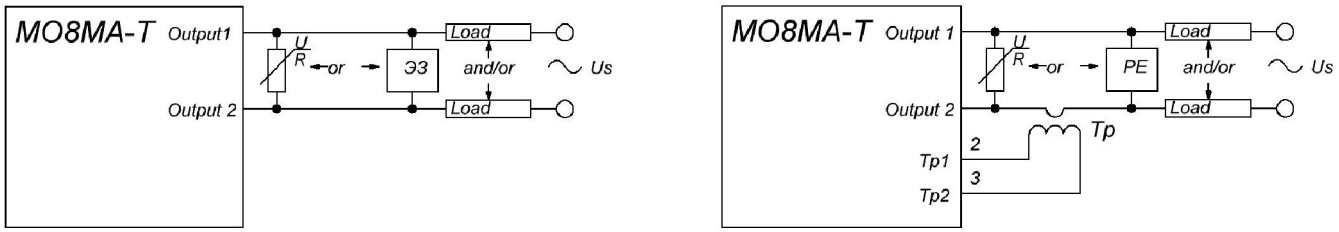


Figure 5.6 – Connection circuit with failure monitoring of control circuit

MO8MA-T provides for input reverse diode of control circuit (Fig. 5.6), whose presence can be used as a failure monitoring of input control circuits and as a failure monitoring of the control line, without module turning-on for power voltage switching.

6 POWER OUTPUTS

Depending on method of switching current measuring by the module we recommend the following connection circuits of power circuits (Fig.6.1).



a) Connection circuit with built-in shunt

b) Connection circuit with external current-measuring transformer

Figure 6.1 – Connection circuits of power outputs

Figure 6.1a shows connection circuit with built-in current-measuring shunt. The range of the module this type includes the modules at 25, 40, 63, 80 A; 12 and 16 class at maximum peak voltage.

Figure 6.1b gives connection circuit with external current-measuring transformer Tr. The range of the module this type includes the modules at 100, 120, 160, 200, 250, 320 A; 12 and 16 class at maximum peak voltage. As a current-measuring transformer the current sensor CS 005.007-4 made by "Energis" Co. Ltd is included in complete kit. Transformation ratio of this sensor is 1:4000, under error ±2%. It is allowed to use current-measuring transformers of the other manufacturers with characteristics that are not worse than the supplied with the module.

To protect the power switching elements against overvoltage it is necessary to install additional protective elements, in the capacity of which it is possible to use a protective varistor or a protective element based on the RC-circuit or semiconductor limiters can be used. Calculation of protective varistor reduces to determination of maximum instantaneous energy attributable to overvoltage pulse, and to determining of maximum classified varistor voltage. The determination of classified varistor voltage reduces to the following formula:

$$U_{cl} = U_n^{rms.} \times \sqrt{2} \times 1.1$$

The permissible regime of module function is when voltage surges on power elements of the module satisfy the following inequality:

$$U_{peak} > U_{cl} + 150V$$

We recommend using the series-produced by Electrum AV Co Ltd protection elements as protection elements based on RC-circuits or semiconductor limiters; they are specially developed under setting dimensions and overall dimensions of MO8MA-T and corresponding current and voltage line. The range of permissible protection elements for MO8MA-T is represented in Table 6.1.

Table 6.1 – Recommended protection elements

Device type	Rated switching current, A									
	25	40	63	80	100	120	160	200	250	320
1200 V	PE1-A1				PE2-A1 (M6)			PE2-A1 (M8)		PE2-A1 (M10)
1600 V	EP1-A0				PE2-A0 (M6)			PE2-A0 (M8)		PE2-A0 (M10)

When self-calculating of protection element you have to take into account that MO8MA-T has protective RC-circuit, whose parameters for different modifications are represented in Table 6.2.

Table 6.2 – Parameters of built-in RC-circuit

Параметры	Classified voltage	
	1200 V	1600 V
R_{sup}	39 Ω	39 Ω
C_{sup}	0.12 μF	0.015 μF

7 SERVICE INSTRUCTIONS

Connection to the module

The power circuit is attached to the module by means of tread contacts. The standard size of the fasteners is shown in Table 7.1. The screws (bolts) should be tightened to the torque (5 ± 0.5) Nm, with mandatory installation of the flat and spring washers, which are included in the supply package.

Table 7.1 – Standard size of the fasteners

Module	Switching current	Fasteners
MO8MA-25-XX-TX	25 A	Screw M5
MO8MA-40-XX-TX	40 A	
MO8MA-63-XX-TX	63 A	
MO8MA-80-XX-TX	80 A	
MO8MA-100-XX-TX	100 A	Screw M6
MO8MA-120-XX-TX	120 A	
MO8MA-160-XX-TX	160 A	
MO8MA-200-XX-TX	200 A	Bolt M8
MO8MA-250-XX-TX	250 A	
MO8MA-320-XX-TX	320 A	Bolt M10

Power cables connection must be made through the connectors that are corrosion-resistant coating, purified from extraneous accretions. After tightening the screws (bolts) it is recommended to fix the connection with paint. It is recommended to re-tighten the screws (bolts) after 8 days and in 6 weeks after the start of operation. Subsequently, the delay should be monitored at least 1 time per a half year.

The mounting of control contacts, ERROR contacts and connection of external current-measuring transformer can be realized by means of soldering or knife terminal. The allowable resolderings' numbers of module outputs during edits (assembly) are 3. Output soldering must be made at temperature that does not exceed 235 ° C. Duration of soldering is no longer than 3 s.

When installing and operating it is necessary to take measures to protect the module against exposure of static electricity, when the installing it is obligatory to use the grounding straps and grounding soldering irons of low voltage powered through a transformer by personnel.

Module installation

The module is mounted in the equipment to the cooler (chassis, frame systems, metal plates, etc.) in any orientation using the M5 or M6 screws with torque (5 ± 0.5) Nm, with a mandatory installation of flat and lock washers. When settings the module should be positioned in such a way as to protect it against additional heating of the neighboring elements. It is desirable to orient the planes of cooler ribs in the air flow direction.

The contact surface should have a cooler surface roughness no more than 2.5 μm and the flatness tolerance – not more than 30 μm. The cooler surface should not have any rough edges, honeycombs. No foreign particles should be between the module and the cooler. To improve the thermal balance the module installation on mounting surface or the cooler should be implemented by means of heat-conductive pastes or similar in their heat-conducting properties.

On installation it is necessary to ensure uniformity of the pressing of the module base to the cooler. For this purpose, all screws should be tightened evenly in 2 - 4 methods alternately: first, located on one diagonal, then on the other one. During module disassembling the screw spinning should be produced in the reverse order.

Not earlier than in three hours the mounting the screws must wheeled, respecting the specified torque, as a part of the heat conductive paste outflows under pressure and the fastening may diminish.

It is allowed to install some modules for a cooler without additional layers, under the condition that the power between the outputs of the different modules does not exceed the minimum value of breakdown voltage of each of them when the cooler is grounded.

Below there is Table 7.2 of conformity MO8MA-T, power loss on it and the necessary area without additional blow-off.

Table 7.2 – Necessary dimensions of the cooler for MO8MA-T of different types T = 25 °C

Module	Loss power at maximum load, max, W	Cooler	
		HS153	HS271
MO8MA-25-XX-TX	40	HS153-110	HS271-50
MO8MA-40-XX-TX	65	HS153-110	HS271-110
MO8MA-63-XX-TX	95	HS153-110	HS271-110
MO8MA-80-XX-TX	120	HS153-110	HS271-150
MO8MA-100-XX-TX	150	HS153-150	HS271-250
MO8MA-120-XX-TX	180	HS153-150	HS271-250
MO8MA-160-XX-TX	240	HS153-250	HS271-300
MO8MA-200-XX-TX	300	HS153-250	HS271-500
MO8MA-250-XX-TX	375	HS153-300	HS271-500
MO8MA-320-XX-TX	480	HS153-400	-

The smaller cooler dimensions are assumed in the event that the module operates at less than the maximum load, or if the forced cooling is provided.

Requirements for operation

The module should only be used in exposure to mechanical loads in accordance with Table 7.3.

Table 7.3 – Impact of mechanical loads

External exposure factor	Value of external exposure factor
Sinusoidal vibration: - acceleration, m/s^2 (g); - frequency, Hz	 100 (10) 1 - 500
Mechanical shock of repeated action : - peak impact acceleration , m/s^2 (g); - duration of impact acceleration, ms	 400 (40) 0.1 – 2.0
Linear acceleration, m/s^2 (g)	5000 (500)

The module should be used under the influence of climate loads in accordance with Table 7.4.

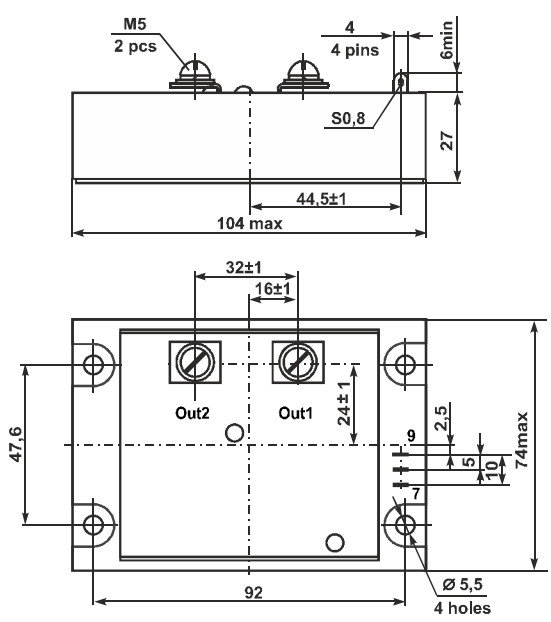
Table 7.4 – Impact of climate loads

Climatic factor	Value of climatic factor
Low temperature of environment: - operating, °C; - maximum, °C	 - 40 - 45
High temperature of environment: - operating, °C; - maximum, °C	 + 85 + 100
Relative humidity at a temperature 35 °C non-condensing %, max	98

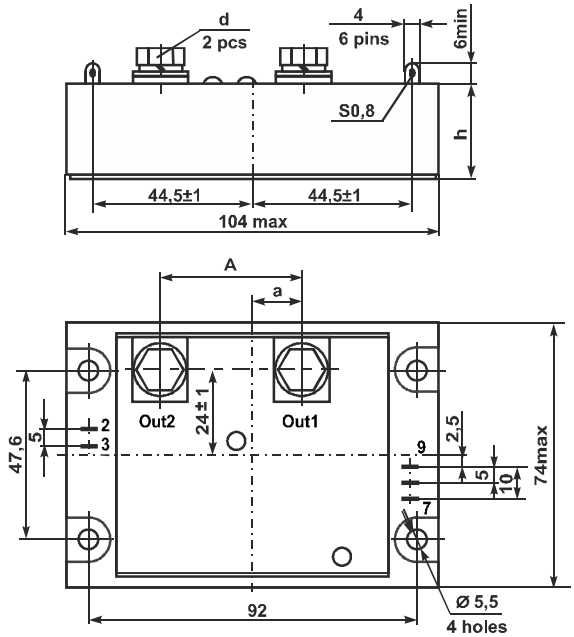
Safety Requirements

1. Operation with the module should be carried out only by qualified personnel.
2. Do not touch the module power outputs of the supply voltage applied, even if the motor is stopped.
3. Do not connect or disconnect wires and connectors while on the power circuit is energized.
4. Connect the oscilloscope probe only after removal of the power voltage and discharge of filter capacity.
5. Do not disassemble or modify the module. If it is necessary please contact to the manufacturer.
6. Not allowed to touch the module if it is supplied by the mains supply and the radiator is not grounded.
7. Do not touch the radiator because its temperature can be very high.
8. Avoid penetrating water and any liquids on the module.

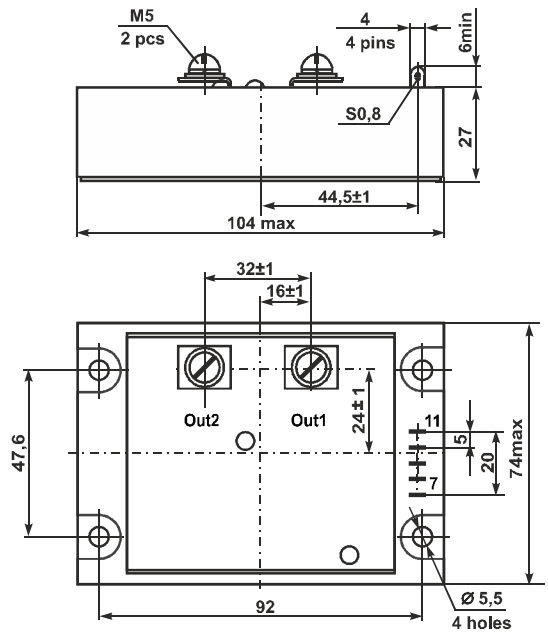
8 OVERALL AND CONNECTING DIMENSIONS



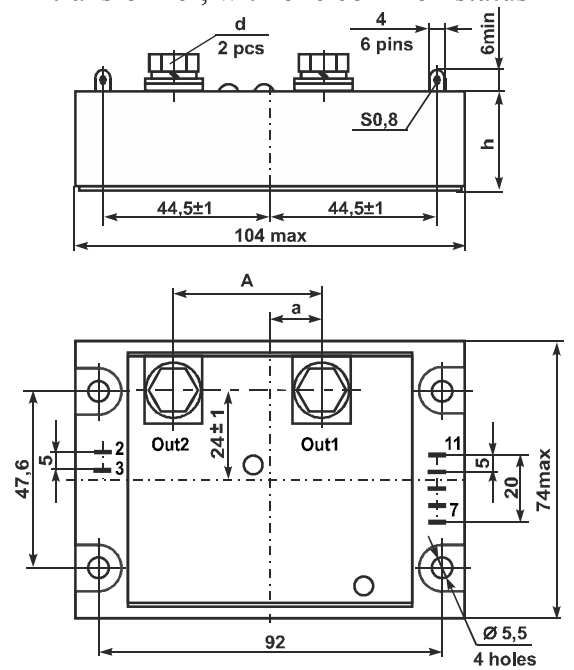
a) module with built-in current-measuring shunt, with one common status



b) module with external current-measuring transformer, with one common status



c) module with built-in current-measuring shunt, with three separate statuses



d) module with external current-measuring transformer, with three separate statuses

Figure 9.1 – Overall and connecting dimensions

Table 9.1 – Connecting dimensions

Module	Figure	A,mm	a, mm	h, mm	d, mm
MO8MA-25-XX-TX	9.1 a, c	-	-	-	
MO8MA-40-XX-TX	9.1 a, c	-	-	-	
MO8MA-63-XX-TX	9.1 a, c	-	-	-	
MO8MA-80-XX-TX	9.1 a, c	-	-	-	
MO8MA-100-XX-TX	9.1 b, d	40±1	20±1	27	Screw M6
MO8MA-120-XX-TX	9.1 b, d	40±1	20±1	27	Screw M6
MO8MA-160-XX-TX	9.1 b, d	40±1	20±1	27	Screw M6
MO8MA-200-XX-TX	9.1 b, d	40±1	14.5±1	29	Screw M8
MO8MA-250-XX-TX	9.1 b, d	40±1	14.5±1	29	Screw M8
MO8MA-320-XX-TX	9.1 b, d	41±1	19±1	29	Screw M10

Precious metals are not contained.

9 CONTENT OF NON-FERROUS METALS

The module contains the non-ferrous metals: Copper…….. g.
Brass ……... g.

10 SUPPLY PACKAGE

Module _____ _____ pcs

Current sensor
CS 005.007-4* _____ _____ pcs

User's manual _____ _____ pcs

***for currents from 100, 120, 160, 200, 250, 320 A.**

11 RELIABILITY SPECIFICATIONS

Reliability probability of the module for 25000 hours must be at least 0.95.
Gamma-percent life must be no less than 50000 hours by $\gamma = 90$ %.
Gamma-percent service life of the modules, subject to cumulative operating time is not more than gamma-percent life, not less than10 years, at $\gamma = 90$ %.
Gamma-percent storageability time of the modules, at $\gamma = 90$ % and storing – 10 years.

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